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META-ANALYSIS

Impact of digital addiction on youth health: A systematic review and meta-analysis

BLEN DEREJE SHIFERAW[1†], JIE TANG[2†], YINGXUE WANG[1], YIHAN WANG[1], YUHAO WANG[1], LOUISA ESI MACKAY[1], YUNJIAO LUO[1], NA YAN[1], XINYU SHEN[3], TONG ZHOU[4], YIRAN ZHU[1], JIALIN CAI[1], QINGZHI WANG[1], WENJUN YAN[1], XIUYIN GAO[1], HAIFENG PAN[5] and WEI WANG[1,6,7*]

[1] School of Public Health, Xuzhou Medical University, Xuzhou, Jiangsu, China

[2] Medical Department, Nanjing Jiangbei Hospital, Nanjing, Jiangsu, China

[3] School of Public Health, Southeast University, Nanjing, Jiangsu, China

[4] School of Public Health, Capital Medical University, Beijing, China

[5] School of Public Health, Anhui Medical University, Hefei, Anhui, China

[6] Research Center for Psychological Crisis Prevention and Intervention of College Students in Jiangsu Province, China

[7] Engineering Research Innovation Center of Biological Data Mining and Healthcare Transformation, Jiangsu, China

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ABSTRACT

Background and aims: Digital addiction among youth, characterized by excessive and compulsive use of digital devices such as smartphones, computers, and social media platforms, has become a global concern. The present study aimed to investigate the association between digital addiction subtypes in youth and various health outcomes using "digital addiction" as an umbrella term. *Methods:* We comprehensively reviewed articles reporting health outcomes related to digital addiction in youth from the Chinese National Knowledge Infrastructure (CNKI), Wanfang, PubMed, and Web of Science databases using a targeted search strategy and assessed them using predefined inclusion and exclusion criteria. *Results:* Youth with digital addiction were more likely to be overweight or obese (OR: 1.25, 95% CI: 1.03–1.48), reporting poor self-rated health (OR: 1.75, 95%CI: 1.42–2.08), and experience sleep problems such as insomnia (OR: 1.46, 95%CI: 1.33–1.59) and poor sleep quality (OR: 1.50, 95%CI: 1.37–1.64). These individuals also demonstrated higher odds of mental health concerns, including suicidal tendencies (OR: 2.63, 95%CI: 2.36–2.90), symptoms of depression (OR: 1.76, 95%CI: 1.68–1.83), stress (OR: 2.15, 95%CI: 1.79–2.52), and anxiety (OR: 2.14, 95%CI: 1.99–2.28). Furthermore, they were more prone to engage in smoking (OR: 1.55, 95%CI: 1.41–1.68), problematic alcohol consumption (OR: 1.47, 95%CI: 1.33–1.60), and drug use (OR: 1.94, 95%CI: 1.44–2.44). *Conclusions:* The present findings suggest that digital addiction among youth has a significant and wide range of detrimental health outcomes, including physical, mental, and behavioral issues.

KEYWORDS

meta-analysis, youth, digital addiction, health

†These authors have contributed equally to this work and share the first authorship.

*Corresponding author.
E-mail: weiwang90@163.com

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INTRODUCTION

The rapid technological advancements of the 21st century have ushered in an era dominated by digital platforms and devices, fundamentally transforming the way youth engage with the world. Unlike previous technological revolutions, the proliferation of smartphones, tablets, and ubiquitous internet access has created an always-connected reality—the "digital age" (K. Ding & Li, 2023). Digital devices are not limited by time and space; they can be used anytime and anywhere to socialize, shop, surf, or play games online. The rise of digital technology, particularly through social networking tools, text messaging, and the Internet (George, Russell, Piontak, & Odgers, 2018), has significantly increased the number of active digital users. As of April 2023, there were 5.18 billion Internet users, of whom 4.8 billion used social media (59.9% of the world's population) (Petrosyan, 2023). Moreover, teenagers are even more enthusiastic users of the Internet, smartphones, and social media (Odgers & Jensen, 2020). Teenagers' high engagement with digital devices reflects their drive for social connection, self-expression, and exploration, which are key aspects of adolescent development (Davel, 2017; Manago & McKenzie, 2022). Studies show that social media, in particular, fulfils teenagers' needs for social validation and identity formation, making it an appealing and sometimes addictive space (Granic, Morita, & Scholten, 2020; Valkenburg & Piotrowski, 2017).

Northern Europe has 98% Internet usage among 15–24-year-olds, making it the region with the highest Internet usage among young people globally (Petrosyan, 2023). Almost every teenager in the United States has a smart device (95%) (Odgers & Jensen, 2020). Similarly, the China Internet Network Information Center released a parallel report stating that, by 2021, China's Internet penetration rate among minors would reach 96.8% (Center, 2022). Undeniably, these digital devices bring great convenience to children's learning and lives; however, the consequent digital addiction also has various adverse effects (K. Ding & Li, 2023).

Digital addiction is a general umbrella term that refers to addictive behavior associated with digital devices, including smartphone addiction (SA), internet addiction (IA), game addiction (GA), and social media addiction (SMA) (Ali, Jiang, Phalp, Muir, & McAlaney, 2015; Meng et al., 2022). New forms of addiction have emerged due to the growing use of new digital technologies, such as social media and smartphones (Andreassen, 2015; Chóliz, 2010). Today reports on all subtypes of digital addiction among youth are on the rise (Christakis, 2010; Endomba et al., 2022; Fam, 2018; Fischer-Grote, Kothgassner, & Felnhofer, 2019; Mihara et al., 2016; Vigna-Taglianti et al., 2017). The scope of such addictions has consolidated into a much broader term—"digital addiction" (Basel, Mcalaney, Skinner, Pleva, & Ali, 2020; Christakis, 2019). The global prevalence of IA varies from 7.9 to 40.3% (Christakis, 2010; Endomba et al., 2022; Mihara et al., 2016; Vigna-Taglianti et al., 2017), with the variation in the reported prevalence of SA among adolescents ranging from 5% to approximately 50% (Fischer-Grote et al., 2019). Furthermore, another meta-analysis spanning 30 years showed that the global prevalence of GA among adolescents was 4.6% (Fam, 2018).

Youth may be at an elevated risk of digital addiction because of their developmentally expected focus on finding their identity and establishing social relationships, according to Erikson's stages of psychosocial development (Orenstein & Lewis, 2024). Biologically, their early stage of brain development also predisposes youth to impulsive behaviors, further elevating their risk (Marin, Nuñez, & de Almeida, 2021; Vigna-Taglianti et al., 2017; J. Wang et al., 2022). When youth are overly engaged in the online world, they may gradually experience a reduced capacity to interact with people in the real world, which has been linked to "social withdrawal" behaviors and associated negative consequences (Kato, Shinfuku, & Tateno, 2020; Tateno et al., 2019). In many countries, the health problems associated with digital addiction in youth have become increasingly difficult to ignore (K. Ding & Li, 2023). Numerous studies have reported that digital addiction is connected with significant challenges in daily life and may be associated with adverse effects on personal health (Y. Ding et al., 2022; Dresp-Langley & Hutt, 2022; Masaeli & Billieux, 2022). Additionally, research has found associations between digital addiction and functional impairments, as well as psychological difficulties such as attention deficit hyperactivity disorder (B. Q. Wang, Yao, Zhou, Liu, & Lv, 2017), depression (Li, Li, Liu, & Wu, 2020), and anxiety (Lopes et al., 2022), among others. Moreover, a meta-analysis published in 2018 found that individuals with Internet Addiction (IA) were approximately 2.81 times more likely to report suicide attempts compared to those without IA (Y. S. Cheng et al., 2018). Although previous reviews have compiled studies on the associations between digital media use and mental health outcomes (Marciano, Ostroumova, Schulz, & Camerini, 2021), or explored links between digital addiction and specific health conditions (Dresp-Langley, 2020; Lissak, 2018; Mylona, Deres, Dere, Tsinopoulos, & Glynatsis, 2020), these studies have been limited to the effects on one aspect of health and have not systematically discussed the effects of youth digital addiction on all aspects of their health.

To address this gap, we conducted a systematic review and meta-analysis to measure the association between digital addiction across subtypes and health outcomes in youth. The primary outcomes of interest were pooled measures of the relationship between digital addiction and health outcomes. Following precedent in literature (T. Karakose, Tülübaş, & Papadakis, 2022; Turgut Karakose, Yıldırım, Tülübaş, & Kardas, 2023), we used Digital Addiction as a general inference for addiction subtypes (SA, IA, GA, or SMA) analyzed in this study to understand the broader implications of digital addiction on youth health.

METHODS AND MATERIALS

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) standard protocol and guidelines were followed (Page et al., 2021). Two Chinese databases, (1) the Chinese National Knowledge Infrastructure (CNKI) and (2) Wanfang, and two English databases, (1) PubMed and (2) Web of Science, were utilized for the search to yield relevant studies from their inception to April 2024. Articles were required to be in one of these two languages. Detailed information on the search strategy (keywords) of this systematic review and meta-analysis is provided in Table S1 in the Supplementary Materials. The key words searches were focused on 3 categories (1) "internet addiction" ("internet overuse" OR "problematic internet use" OR "internet addiction disorder" OR "pathological internet use" OR "excessive internet use" OR "compulsive internet use" OR "internet dependency" OR "internet gaming addiction" OR "internet gaming disorders" OR "computer addiction" OR "internet use disorder" OR "media addiction" OR "smartphone addiction" OR "electronic device addiction" OR "mobile addiction OR phone addiction") AND (2) "Youth" ("youth" OR "youths" OR "adolescent" OR "adolescents" OR "teenager" OR "teenagers" OR "child OR children" OR "student" OR "students") AND (3) "substance use" OR "sexual health" OR "mental health" OR "weight and physical exercise" OR "violence" OR "physical health status and conditions." This search strategy (Table S1) yielded 11,856 articles, of which 8,990 were unique reports retrieved after deleting duplicate articles. In cases in which eligibility could not be determined based on the title and abstract, we examined the full text. The initial literature search was performed by two reviewers, who then retrieved and independently screened the full-text articles. Conflicts over inclusion were resolved through discussion with a third reviewer.

Selection criteria

We included studies that (1) assessed any form of digital addiction, with valid definitions and measurement tools used; (2) assessed digital addiction defined as a general inference or as other subtypes measured (e.g., SA, IA, GA, or SMA); (3) assessed health problems observed in digitally addicted youth; (4) focused predominantly on youth (McCabe et al., 2023) with a mean age ≤ 25 years; (5) reported odds ratios (ORs), comparable statistics (hazard ratios or prevalence ratios), or data to enable their calculation for a health outcome. We did not limit the studies based on study design; therefore, studies with interventions were included in this meta-analysis. In our narrative review, we included studies that were within the prospects of our research question but without published data presenting the odds ratios (ORs) or adequate information to allow their calculation, listing the reasons for exclusion from the meta-analysis. The other studies were grouped according to the relationship between health outcomes and digital addiction.

Data collection and quality assessment

Two investigators independently screened the titles and abstracts to identify potentially eligible articles and then checked the full texts to determine the final inclusion. For the included studies, both reviewers independently extracted data regarding study characteristics (author, year of publication, country, study type, population, sample size, age range, sex, prevalence rate, subtype classification, odds ratios [ORs], and 95% CIs for health outcomes).

Two reviewers independently assessed the quality of the included studies. We used the Newcastle-Ottawa Scale (NOS) (Stang, 2010) as a quality assessment tool to evaluate the risk of bias in case-control studies, cohort studies, and the Joanna Briggs Institute (JBI) (Zeng et al., 2015) tool to assess the methodological quality of cross-sectional studies, as recommended by the Cochrane Collaboration. A score of *out of 9* represented the scale, with higher values indicating better study quality. The NOS contains three main modules: selection of subjects, comparability, and exposure/outcome. Each module had evaluation entries, each with a maximum score of 1* and comparability with a maximum of 2*. We excluded some high-risk studies (e.g., quality assessment scores ≤ 3) using quality assessment scales to reduce the risk of bias associated with selective sampling.

Statistical analysis

We analyzed Digital Addiction as a general inference for all subtypes of addiction (SA, IA, GA, or SMA) in the meta-analysis and pooled ORs with 95% CIs for health outcomes selected using the combined effect scale in Stata 17.0 software. The meta-analysis used a random-effects model to allow more general inferences to be made about the population of possible studies rather than the specific participants studied. When ORs were presented at the subtype level within the samples, we pooled the ORs before the analysis. We used the I^2 statistic to estimate the effect of heterogeneity among the pooled studies. We performed a sensitivity analysis by excluding studies individually. Forest plots showing ORs and 95% CIs for each study and the overall random-effects pooled estimate were generated. Additionally, we explored the risk of publication bias using Egger's and Begg's tests, and a funnel plot was drawn for visual inspection (see Table S3, Fig. S1 in the supplementary material).

Ethics

This study did not involve human or animal subjects, and thus, no ethical approval was required. The study protocol adhered to the guidelines established by the journal.

RESULTS

The study selection process for meta-analysis and narrative review

A total of 11,856 records were identified through database searches (753 from CNKI, 1,503 from Wanfang, 7,805 from Web of Science, and 1,795 from PubMed). After excluding 2,866 duplicate publications, 8,990 articles were screened (Fig. 1). Full-text copies of 529 articles were assessed after removing irrelevant articles based on title and abstract review; 172 were selected to contribute to the review, 155 studies contained relevant results that met the meta-analysis criteria, and 17 studies were summarized and reported separately.

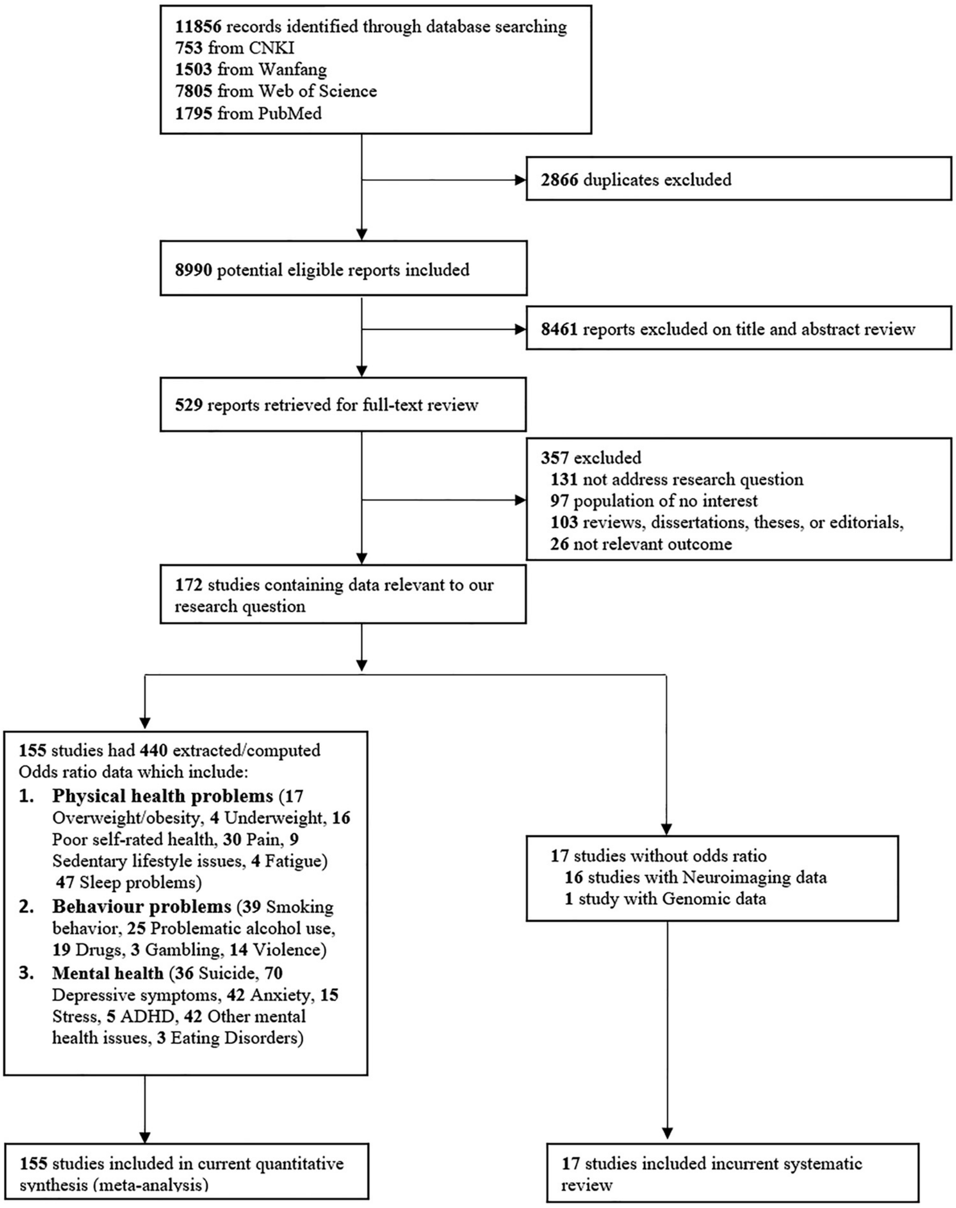

Fig. 1. PRISMA Flow Diagram of the Literature Search Process

Characteristics of studies included in the meta-analysis

Table 1 presents details pertaining to the included studies, including prevalence rates, age, sample size, population, and digital addiction subtypes. The articles examined focused on the prevalence rates of digital addiction subtypes, including Internet Addiction (IA), Gaming Addiction (GA), Social Media Addiction (SMA), and Smartphone Addiction (SA), among diverse populations across various countries. The global mean prevalence of digital addiction was reported, with country-specific prevalence rates ranging from 1.3% (E. A. Abo-Ali et al., 2022) in India to 88.25% (D. Ayar et al., 2017) in Bangladesh. This disparity may be influenced by prejudice due to different Internet Addiction Scales used in separate studies. The meta-analysis encompassed 155 studies with a total sample size of 1,541,883 participants, comprising both males and females, with a mean age of 17.44 ± 3.70 years across 39 nations. China contributed the largest number of studies, with 50 studies (32.3%) utilizing population samples from the country. Of the 155 studies included, 146 (94.2%) employed cross-sectional study designs, 6 (3.9%) utilized cohort studies, and 3 (1.9%) implemented case-control studies. Regarding population type, 65 studies (41.9%) focused on university student populations, approximately 67 studies (43.2%) targeted school students (elementary, middle, and high school students), and the remaining 23 studies (14.8%) involved

Table 1. Characteristics of included studies

Study	Country	Study type	Population	Sample size (n)	Age (years)	Prevalence rate	Subtype
Ehab A. Abo-Ali et al. (2022)	Saudi Arabia	CS	University students	408	20.50 ± 1.42	66.90%	SA
Dijle Ayar et al. (2017)	Turkey	CS	High school students	910	13–18	IA: 27.4%	IA and SA
A. Alageel, Alyahya, Bahatheq, Alzunaydi, and Iacobucci (2020)	Middle Eastern	CS	Postgraduate students	506	≥21	51.00%	SA
Alotaibi, Fox, Coman, Ratan, and Hosseinzadeh (2022)	Saudi Arabia	CS	Undergraduate students	545	≤21	67.00%	SA
Al Shawi et al. (2021)	Iraq	CS	Medical students	305	21.4 ± 1.8	71 .8%	IA
J. An et al. (2014)	China	CS	Secondary school students	13,723	15.26 ± 1.67	11.70%	IA
Udeme Asibong et al. (2020)	Nigeria	CS	Undergraduate students	418	21.5 ± 3.6	IA:20.10%	IA and SMA
Aşut, Abuduxike, Acar-Vaizoğlu, and Cali (2019)	Turkish Republic of Northern Cyprus	CS	Secondary school students	469	11.95 ± 0.81	18.10%	IA
Thummaporn Boonvisudhi and Sanchai Kuladee (2017)	Thailand	CS	Medical students	705	20.51 ± 1.91	24.40%	IA
Buke, Egesoy, and Unver (2021)	Turkey	CS	University students	300	21.36 ± 2.33	42.00%	SA
Cai, Xi, Zhu, Wang, and Xiang (2021)	China	CS	University students	1,070	19.7 ± 1.4	23.30%	IA
Rita Cerutti, Fabio Presaghi, Valentina Spensieri, Carmela Valastro, and Vincenzo Guidetti (2016)	Italy	CS	Middle school students	841	10–16	SA: 5.23% IA: 19.86%	IA and SA
Hsiao Ching Chen, Jiun Yi Wang, Ying Lien Lin, and Shang Yu Yang (2020)	China	CS	Fifth and sixth-grade students	451	11.35 ± 0.56	33.70%	IA
S. H. Cheng et al. (2012)	China	CS	Incoming university students	4,318	NA	13.43%	IA
Choi et al. (2009)	South Korea	CS	High school students	2,336	16.7 ± 1.0	2.20%	IA
Chung et al. (2018)	South Korea	CS	Middle schools and high schools	1,796	14.9 ± 1.8	19.50%	SA
de Paula et al. (2022)	Brazil	CS	University students	356	NA	23.90%	IA
Do, Lee, and Lee (2017)	South Korea	CS	Middle and high school students	49,324	13–18	23.27%	IA
Do and Lee (2018)	South Korea	CS	Youth	73,238	13–18	2.97%	IA
H. Dong, Yang, Lu, and Hao (2020)	China	CS	Children and adolescents	2,050	12.34 ± 4.67	33.37%	IA
Ekinci, Çelik, Savaş, and Toros (2014)	Turkey	CS	High school students	1,212	16 ± 0.98	2.60%	IA
Eliacik et al. (2016)	Turkey	CC	Adolescents	135	13–18	35.56%	IA
Esen, Kutlu, and Cihan (2021)	Turkey	CS	University students	1,257	21.12 ± 1.96	16.8%	IA
Evren, Dalbudak, Evren, and Demirci (2014)	Turkey	CS	Adolescents	4,957	15.58 ± 2.85	15.96%	IA
Fernández-Villa et al. (2015)	España	CS	University Students	2,780	20.3 ± 4.4	6.08%	IA
Gansner et al. (2019)	America	CS	Adolescents	205	15.5	72.70%	IA
L. Guo et al. (2018)	China	CS	Adolescents	20,895	15.19 ± 1.84	NA	IA
M. Gao et al. (2022)	China	CS	Adolescents	7,990	≤15, ≥18	13.40%	IA
T. Gao et al. (2020)	China	CS	High school students	2,272	15.99 ± 0.91	7.00%	IA
Garakani, Zhai, Hoff, Krishnan-Sarin, and Potenza (2021)	America	CS	High school students	2,005	14–18	15.90%	GA
Ge, Se, and Zhang (2014)	China	CS	Adolescents	796	NA	10.80%	IA

(continued)

Table 1. Continued

Study	Country	Study type	Population	Sample size (n)	Age (years)	Prevalence rate	Subtype
J. Guo et al. (2012)	China	CS	NA	3,254	8–17	13.30%	IA
W. Guo et al. (2020)	China	CS	First-year undergraduates	31,659	15–23	37.93%	IA
G. Han et al. (2021)	China	CS	Adolescents	31,954	12–18	6.20%	IA
Heidarimoghadam et al. (2020)	Iran	CS	University students	665	22.12 ± 0.15	IA:32.80%	IA, GA and SMA
Hossin, Islam, Billah, Haque, and Uddin (2022)	Sweden	CS	University students	625	22.5 ± 2.4	25.90%	IA
Huang et al. (2020)	China	CS	Adolescents	12,507	16.6 ± 0.8	27.52%	IA
Hu et al. (2022)	China	CS	Adolescents	2,149	14–18	NA	IA
Iwasaki, Kakuta, and Ansai (2022)	Japan	CS	Adolescents	1,562	NA	26.00%	IA
Karimy et al. (2020)	Iran	CS	University students	279	21.01 ± 3.17	39.00%	IA
Khalil, Kamal, and Elkholy (2022)	Egypt	CS	High school students	584	14–18	65.60%	IA
H. J. Kim, Min, Kim, and Min (2019)	South Korea	CS	University students	608	22.8	36.50%	SA
K. M. Kim, Kim, Choi, Kim, and Kim (2020)	South Korea	CS	Adolescents	223,542	12–18	5.20%	IA
Ko et al. (2006)	China	CS	Adolescents	3,662	11–21	19.28%	IA
Kojima et al. (2019)	Japan	CS	Junior high-school students	2,789	12–15	17.78%	IA
Koyuncu, Unsal, and Arslantas (2014)	Turkey	CS	Secondary and high school students	1,157	15.13 ± 1.71	7.87%	IA
Krishna et al. (2019)	India	CS	Undergraduate dental students	1,530	NA	1.30%	SA
S. Kumar et al. (2018)	India	CS	Dental students	349	21.19 ± 1.93	6.02%	IA
G. Kumar et al. (2022)	India	CS	College students	475	18.81 ± 1.19	23.60%	IA
Lam, Peng, Mai, and Jing (2009)	Australia	CS	Adolescents	1,639	13–18	10.80%	IA
Lau, Wu, Gross, Cheng, and Lau (2017)	China	C	Secondary students	1,545	NA	18.10%	IA
M. P. Lin, Wu, You, Hu, and Yen (2018)	China	CS	Senior high schools	2,170	15.83 ± 0.38	17.40%	IA
Malak and Khalifeh (2018)	Jordan	CS	Jordanian school students	800	14.92 ± 1.69	65.89%	IA
M. A. Mamun et al. (2019)	Bangladesh	CS	University students	405	20.2 ± 1.61	32.60%	IA
M. A. Mamun et al. (2020)	Bangladesh	CS	University students	605	20.26 ± 2.08	16.50%	IA
Mustafaoglu, Yasaci, Zirek, Griffiths, and Ozdincler (2021)	Turkey	CS	University students	249	18–25	37.00%	SA
Nguyen, Yang, Lee, Nguyen, and Kuo (2022)	Vietnam	CS	Adolescents	678	16.1 ± 0.9	30.70%	IA
Nunes et al. (2021)	Brazil	CS	Adolescents	286	15–19	70.30%	SA
Ohayon and Roberts (2021)	USA	CS	Undergraduate and graduate students	2,984	22.9 ± 5.7	39.40%	GA
Okasha et al. (2022)	Egypt	CS	University students	1,380	18–26	59.57%	SA
Otsuka, Kaneita, Itani, and Tokiya (2020)	Japan	C	Adolescents	1,547	NA	22.00%	IA
Otsuka et al. (2021)	Japan	CS	Adolescents	248,983	12–18	12.07%	IA
Özparlak and Karakaya (2022)	Turkey	CS	Adolescents	638	14–19	16.90%	IA
Peltzer, Pengpid, and Apidechkul (2014)	Thailand	CS	University students	860	18–25	35.30%	IA
Pengpid and Peltzer (2018)	Thailand	CS	University students	3,148	20.5 ± 1.6	35.60%	IA
Pereira, Bevilacqua, Coimbra, and Andrade (2020)	Brazil	CS	Adolescents	667	13–18	22.64%	SA

(continued)

Table 1. Continued

Study	Country	Study type	Population	Sample size (n)	Age (years)	Prevalence rate	Subtype
Phomprasith et al. (2022)	Thailand	CS	University students	706	20.6 ± 2.0	SA:59.50% GA:5.10%	SA and GA
Poorolajal et al. (2019)	Iran	CS	University students	4,261	22.17 ± 3.18	27.30%	IA
Ramón-Arbués et al. (2021)	Spain	CS	University students	698	21.96 ± 5.43	21.20%	IA
Restrepo et al. (2020)	America	CS	Adolescents	564	7–15	21.99%	IA
Rücker, Akre, Berchtold, and Suris (2015)	Switzerland	CS	Adolescents	3,067	14	11.74%	IA
Saffari et al. (2022)	China	CS	Female university students	391	22.85 ± 4.03	62.90%	SA
Saikia, Das, Barman, and Bharali (2019)	India	CS	Adolescents	416	16–19	80.77%	IA
Seyrek, Cop, Sinir, Ugurlu, and Şenel (2017)	Turkey	CS	Adolescents	432	12–17	17.80%	IA
Shen et al. (2021)	China	CS	College students	8,098	17–25	7.74%	IA
Shinetsetseg, Jung, Park, Park, and Jang (2022)	South Korea	CS	Middle- and high-school students	54,948	NA	2.97%	SA
Stevens, Zhang, Cherkerzian, Chen, and Liu (2020)	USA	CS	University students	43,003	NA	IA and GA:10.70%	IA and GA
Sung, Lee, Noh, Park, and Ahn (2013)	South Korea	CS	Adolescents	73,238	NA	3.00%	IA
Suris et al. (2014)	Switzerland	CS	Adolescents	3,067	NA	11.70%	IA
Taha, Shehzad, Alamro, and Wadi (2019)	Saudi Arabia	CS	College students	209	NA	21.40%	IA
Tran et al. (2017)	Vietnam	CS	Young people	566	15–25	21.20%	IA
Tsitsika et al. (2011)	Greece	CC	Adolescents	129	11–18	67.00%	IA
Tzang, Chang, and Chang (2022)	China	CS	Children	102	7–18	52.00%	GA
Ustinavičienė et al. (2016)	Lithuania	CS	Adolescents	1,730	13–18	IA: 9.15%	IA and GA
Venkatesh, Jemal, and Samani (2017)	Saudi Arabia	CS	University students	189	23.29	71.96%	SA
Vigna-Taglianti et al. (2017)	Italy	CS	High school students	2,022	16.2	12.15%	IA
W. Wang et al. (2019)	China	CS	High school students	26,688	15–20	28.4%%	IA
Xu et al. (2020)	China	CS	Secondary school students	2,892	15.1 ± 1.7	23.70%	IA
S. Y. Yang, Fu, Chen, Hsieh, and Lin (2019)	China	CS	Junior college students	503	15–22	66.60%	IA
X. Yang et al. (2022)	China	C	University student	12,043	15–23	5.47%	IA
B. Yao, Han, Zeng, and Guo (2013)	China	CC	College students	977	21.39	NA	IA
Ye et al. (2016)	China	CS	College students	2,422	19.7 ± 1.2	22.30%	IA
Yen, Ko, Yen, and Cheng (2008)	China	CS	Adolescents	8,004	12–18	IA: 11.11% SA: 12.36%	IA and SA
J. Y. Yen, Ko, Yen, Chen, et al. (2008)	China	CS	Adolescents	3,662	15.48 ± 1.65	19.80%	IA
Younes et al. (2016)	Lebanon	CS	University students	600	18–28	16.80%	IA
Yücens and Üzer (2018)	Turkey	CS	University students	392	NA	27.00%	IA
Zenebe et al. (2021)	Ethiopia	CS	University students	603	21.4 ± 1.8	85.00%	IA
Zhang, Hao, Liu, Cui, and Yu (2022)	China	CS	University students	1,629	23.85 ± 3.53	58.50%	SA
Zhang et al. (2021)	China	CS	Graduate students	1,016	25.75 ± 2.35	49.70%	SA
M. Zhang, Hao, Liu, Cui, and Yu (2022)	China	CS	Medical students	2,741	21.75 ± 1.99	33.00%	SA
Y. Zhao et al. (2021)	China	CS	University students	11,254	20.0 ± 1.3	28.40%	IA

(continued)

Table 1. Continued

Study	Country	Study type	Population	Sample size (n)	Age (years)	Prevalence rate	Subtype
Daniyal, Javaid, Hassan, and Khan (2022)	Pakistan	CS	University students	400	24.45 ± 3.45	NA	SA
Mahmoodi et al. (2018)	Iran	CS	High school students	1,034	16.19	60.35%	SA
Pattanaseri, Atsariyasing, Pornnoppadol, Sanguanpanich, and Srifuengfung (2022)	Thailand	CS	Medical students	224	21.02	SMD: 22.3% GA: 4.5%	SMA&GA
Sharma, Amandeep, Mathur, and Jeenger (2019)	India	CS	High school students	1,386	15.5	46.9%	SA
Albikawi (2023)	USA	CS	University students	96	20.8 ± 1.62	49.16%	IA
Aleebrahim, Daneshvar, and Tarrahi (2022)	Iran	CS	High school students	903	16.51 ± 0.90	33.1%	IA
Borges et al. (2023)	Mexico	C	First-year university students	1,731	≥18	6.60%	IA
Çelik and Haney (2023)	Turkey	CS	Athlete university students	501	21.45 ± 3.19	34.40%	IA
Frydenlund, Guldager, Frederiksen, and Egebæk (2023)	Denmark	CS	University students	5,700	≥18	23.00%	SA
Islam, Hasan Apu, et al. (2023)	Bangladesh	CS	School-going adolescents	502	10–16	88.25%	IA
Islam, Tushar, et al. (2023)	Bangladesh	CS	School-going adolescents	4 91	10–16	80.04%	IA
Jeong et al. (2023)	Korea	CS	Adolescents	54,948	12–18	25.50%	SA
Lakhdir et al. (2022)	Pakistan	CS	Youth	1,145	20–24	38.60%	IA
J. Zhao et al. (2022)	China	CS	University students	1,037	19.59 ± 1.59	6.60%	SA
Feng, Chen, and Wu (2023)	China	CS	Middle school students	6,307	14.60 ± 1.74	15.51%	IA
Muslić, Rukavina, Markelić, and Musić Milanović (2023)	Croatia	CS	Adolescents	2,772	16	38.00%	IA
N. F. Mohamed et al. (2023)	Malaysia	CS	Adolescents	5,290	NA	3.50%	GA
Moñino-García et al. (2022)	Spain	CS	Adolescents	2,240	14–18	4.55%	GA
Nahidi et al. (2023)	Iran	CS	University students	355	NA	86.20%	SA
Onukwuli et al. (2023)	Nigeria	CS	Secondary students	851	16.2 ± 1.8	88.10%	IA
Rouleau, Beauregard, and Beaudry (2023)	Canada	C	Adolescents	247	12–17	10.93%	SMA
Mahmoud et al. (2023)	Saudi Arabia	CS	Youth	800	25.85 ± 8.25	NA	SMA
Sujarwoto, Saputri, and Yumarni (2023)	Indonesia	CS	University students	709	23.64 ± 7.24	NA	SMA
Song et al. (2023)	China	CS	Middle and high school students	60,268	15.10 ± 1.81	58.10%	IA
Q. Wu, Amirfakhraei, et al. (2022)	China	CS	Adolescents	625	14.90 ± 2.09	24.64%	IA
Perez-Oyola et al. (2023)	Peru	CS	Adolescents	505	14.16 ± 1.45	25.94%	IA
Abuhamdah and Naser (2023)	Jordan	CS	University Students	2,337	21–23	56.70%	SA
Liu, Charmaraman, and Bickham (2024)	USA	C	Middle School Students	586	T1:12.5 T2:13.7	T1:55.50% T2: 42.4%	PIU
Mayerhofer et al. (2024)	Austria	CS	Adolescents and Young Adults	913	14–20	38.10%	SA
K. O. Mohamed et al. (2024)	Sudan	CS	Medical Students	307	18–22	75.50%	IA
Ouni et al. (2024)	Tunisia	CS	High School Students	1,399	17 ± 1.5	12.80%	IA
Peng (2023)	China	CS	College Students	780	NA	83.46%	SA

(continued)

Table 1. Continued

Study	Country	Study type	Population	Sample size (n)	Age (years)	Prevalence rate	Subtype
Ran et al. (2024)	China	CS	adolescents and youths	82,873	NA	60.30%	IA
Tan, Deng, Zhang, Peng, and Peng (2023)	China	CS	Middle school students	2,278	12–16	20.30%	IA
Vengadessin, Ramasubramani, and Saya (2024)	India	CS	Medical students	384	18.8 ± 1.5	50.70%	SA
W. Wang et al. (2023)	China	CS	College Students	7,617	18.9 ± 0.84	26.50%	PMPU
L. Yao, Liang, Zhang, and Chi (2023)	China	CS	High School Students	3,156	10–19	20.00%	IA
Yuan et al. (2023)	China	CS	School Student	23,180	9–18	10.30%	IA
C. Zhang et al. (2024)	China	CS	Adolescent	59,859	14.28%	88.10%	IA
L. Zhang et al. (2024)	China	CS	College Students	18,723	NA	29.70%	SA
Y. Zhang et al. (2024)	China	CS	Adolescents	39,731	13.49 ± 0.76	14.90%	IA
Amara et al. (2024)	Tunisia	CS	Middle and high school students	1,353	15–17	26.10%	SMA&GA
Banna et al. (2023)	Bangladesh	CS	University Students	700	23.11	66.60%	IA
Chau, Perrin, and Chau (2024)	France	CS	Middle school students	1,559	13.5 ± 1.3	66.60%	SA
F. Cheng et al. (2024)	China	CS	Middle school students	2,689	11–16	16.00%	IA
Di Carlo et al. (2024)	Italy	CS	Adolescents and young adults	1,076	16–26	26.80%	IA
Dien et al. (2023)	Vietnam	CS	High school students	5,315	11–17	58.10%	IA
Hu, Wu, Wang, Zhou, and Yin (2024)	China	CS	University Students	8,458	NA	NA	SA
Idrees, Sampasa-Kanyinga, Hamilton, and Chaput (2024)	Canada	CS	Middle and high school students	4,748	15.9 ± 1.3	18.30%	IA
Kwon, Kim, and Lee (2023)	Korea	CS	Adolescents	15,343	NA	NA	SA
S. R. Lee, Kim, Ha, and Kim (2023)	Korea	CS	Middle and high school students	54,948	15.23	NA	SA
Cui, Gao, Sun, and Wang (2023)	China	CS	Undergraduate students	562	NA	54.98%	SMA
Shen et al. (2023)	China	CS	Medical students	2,085	NA	40.70%	SMA
Liu et al. (2023)	China	CS	Adolescents	131	15.13	39.69%	IA

Note: CS = cross section, C = cohort study, CC = case-control study, Smartphone addiction = SA, Internet addiction = IA, Game addiction = GA, Social media addiction = SMA.

general youth or mixed population samples. The sample sizes in the studies ranged from 96 to 248,983 individuals, with the majority falling within the moderate to large sample range.

Two reviewers independently assessed the quality of the included studies using the Newcastle-Ottawa Scale (NOS) for cohort and case-control studies and the Joanna Briggs Institute (JBI) tool for cross-sectional studies (Table S2). Among the 172 included studies, 159 studies (92.4%) used a cross-sectional design, indicating a strong reliance on observational, one-time assessments. 7 studies (4.1%) were case-control studies, often used for exploring associations between digital addiction, and 6 studies (3.5%) were longitudinal cohort studies, highlighting a major gap in the literature regarding the long-term effects of digital addiction in youth. The summed quality scores ranged from 4 to 9, with 14 articles obtaining a maximum score of 9. The majority of the included studies were of moderate quality (mean score: 6.8 out of 9). Only 12 studies scored below 5 on the NOS/JBI scales, indicating a higher risk of bias. Lower-quality studies were excluded from the meta-analysis to reduce the potential bias associated with selective sampling. All included studies may have been influenced by prejudice because different articles used different Internet Addiction Scales.

A sensitivity analysis was conducted for the studies, and the results in the appendix were reliable and stable. Funnel plots showing the potential publication bias for outcomes are provided in Fig. S1; some signs of asymmetry were identified in the Figures, possibly due to publication bias, the percentage of variability in effect sizes across studies that is due to true differences (heterogeneity) rather than chance.

Characteristics of studies included in the narrative review

A narrative review of the 17 studies is presented in Table 2. These studies comprised a total of 2,264 participants and were conducted in various countries, with 7 studies (41.2%) from China, 4 studies (23.5%) from South Korea, 3 studies (17.6%) from Germany, and 3 studies (17.6%) from other regions including Indonesia, the United States, and Japan. These studies were excluded from the meta-analysis because of the absence of OR values or insufficient data correlating health problems with digital addiction.

This narrative review encompassed several studies that investigated Game Addiction (GA). Studies by (J. Chen et al., 2020; Park et al., 2017) elucidated the behavioral and neurological aspects of GA, indicating that individuals with these conditions may exhibit impulsivity, impaired response inhibition, and alterations in brain connectivity. Kang, Jung, Park, and Han (2018) observed that GA in youth increased avoidance and anxiety scores, accompanied by changes in functional connectivity between brain regions.

Studies focusing on IA, such as those by (F. Lin et al., 2012; Siste et al., 2022; Liu et al., 2010), revealed that individuals with IA may exhibit heightened sensitivity to rewards, decreased cognitive effort, and structural brain changes, such as lower fractional anisotropy in the corpus callosum and increased regional brain activity in specific brain regions (e.g., the anterior cingulate cortex (ACC) and medial prefrontal cortex (MPFC)). Regarding SA (Hirjak et al., 2022; Horvath et al., 2020; D. Lee, Namkoong, Lee, Lee, & Jung, 2019; Schmitgen et al., 2020; Zou et al., 2021; Zou et al., 2022), and (Y. Wang et al., 2016) elucidated the potential structural and functional brain alterations associated with problematic smartphone use and mobile phone dependence. These alterations include changes in grey matter volume, white matter integrity, cerebral blood flow, and functional connectivity. Collectively, these studies provide insights into the behavioral and neurological characteristics of GA and IA and the brain correlates of SA.

Outcome definitions, outcome numbers, and combined study sample sizes for each outcome

Table 3 shows the included outcomes and associated definitions, along with the number of studies, samples, and countries for each outcome. The health outcome with the largest sample and combined study sample size was "Depressive symptoms," which included 640,820 participants with 70 study samples from 23 countries. Regarding the combined sample size, "Suicide" had the second-largest representation, with 36 outcomes from eight countries and a combined sample size of 540,749 participants. In contrast, less frequently studied outcomes, such as eating disorders, fatigue, and gambling, had relatively fewer study samples, indicating areas that require further investigation. These findings highlight the variations in research focus and sample sizes across different health outcomes, with some areas receiving more attention and having larger sample sizes than others.

Pooled estimates of the association between digital addiction and health outcomes

Figure 2 presents a forest plot depicting the OR and 95% confidence intervals (CI) presented for various health problem outcomes associated with digital addiction. The heterogeneity (I^2) values indicate the degree of variation across the studies. The corresponding forest plots showing the ORs and 95% CIs for each study in various health outcomes are shown in Fig. S3 of the supplementary material.

Regarding weight-related issues, the analysis showed that youth with digital addiction had 25% increased odds of being overweight or obese (OR: 1.25, 95%CI: 1.03–1.48). Concerning general health, youth with digital addiction were more likely to perceive their health as poor (OR: 1.75, 95% CI: 1.42–2.08). Additionally, they also reported a higher prevalence of pain (OR: 1.37, 95%CI: 1.26–1.48) and fatigue (OR: 3.45, 95%CI: 2.33–4.57).

Sleep problems emerged as a significant concern, with digital addiction linked to higher odds of disrupted sleep patterns (OR: 1.38, 95%CI: 1.31–1.44). In addition, digital addiction is associated with an increased risk of substance use and violent behavior. The analysis revealed that people with digital addiction had 55% higher odds of smoking (OR: 1.55, 95%CI: 1.41–1.68), a 47% increased odds of gambling (OR: 1.47, 95%CI: 0.77–2.17), a 47% increased odds of problematic alcohol use (OR: 1.47, 95%CI: 1.33–1.60), a 94% increased odds of drug use (OR: 1.94, 95%CI: 1.44–2.44), and odds of violent tendencies (OR: 1.42, 95%CI: 1.32–1.53).

Furthermore, the impact on mental health and well-being was profound, as digital addiction was associated with elevated odds of suicide (OR: 2.63, 95%CI: 2.36–2.90), depressive symptoms (OR: 1.76, 95%CI: 1.68–1.83), stress (OR: 2.15, 95%CI: 1.79–2.52), anxiety symptoms (OR: 2.14, 95%CI: 1.99–2.28), and attention deficit hyperactivity disorder (ADHD) (OR: 3.47, 95%CI: 2.12–4.82). Other mental health problem outcomes had an OR of 1.75 (95% CI: 1.59–1.91). These results emphasize the potential negative impact of digital addiction on the mental health and overall well-being of the youth.

DISCUSSION

This study presents the results of a comprehensive systematic review and meta-analysis examining the association between digital addiction and various health outcomes in youth. By comparing the outcomes of all assessments, the pooled results revealed that youth who reported digital addiction had significantly greater odds of poor mental and physical health outcomes than those who did not report digital addiction.

Digital addiction and physical health problems

Digital addiction among youth is associated with various adverse physical health outcomes. While substantial evidence links digital addiction to physical health problems in

Table 2. Characteristics of the Studies Included in the narrative review

Author	Summary of Study	Reason for Exclusion from Meta-analysis	Results
J. Chen et al. (2020)	**Study type**: CC; **Age (years)**: 12–18; **Sample size (n)**:48; **Country**: China; **Population:** Adolescents	No OR value or data was determined to calculate the OR of GA-related health problems.	In the Stroop color-word task, adolescents with GA had higher impulsivity and impaired response inhibition. The directed connection of the left DLPFC and dorsal striatum differed significantly between the GA and no-GA groups.
Hirjak et al. (2022)	**Study type**: CS; **Age (years)**: 21.89 ± 2.85; **Sample size (n)**:41; **Country**: Germany; **Population:** University students	Neither a computed OR value nor data to compute the OR value to connect SA-related health issues were reported in the publication.	SA individuals had lower CCF in the right superior frontal gyrus, cACC and rostral anterior cingulate cortex, significantly associated with SA total score and distinct SA subdimensions.
Horvath et al. (2020)	**Study type**: CS; **Age (years)**: 22. 5 ± 3.0; **Sample size (n)**:48; **Country**: Germany; **Population:** General population	The article did not provide an OR value relating to an outcome of SA becoming a health issue.	SA has a negative relationship with both ACC volume and activity and left orbitofrontal GMV.
Kang et al. (2018)	**Study type**: CC; **Age (years)**: 15.6 ± 0.9; **Sample size (n)**:15; **Country**: Korea; **Population:** Adolescents	An OR result was not provided to correlate health issues due to GA.	EAAT significantly improved K-ECRS avoidance and anxiety scores in all adolescents, with increased FC from the left amygdala to the left frontal orbital gyrus and the right amygdala to the right corpus callosum in GA adolescents.
N. Kim et al. (2019)	**Study type**: CS; **Age (years)**:16.63 ± 1.02; **Sample size (n)**:230; **Country**: Korea; **Population:** High school students	An approximate OR result was not provided to associate health problems with GA.	After adjusting for age, the T/S ratio was significantly lower in the GA group than in the non-GA group (150.43 ± 6.20 and 187.23 ± 6.42, respectively; $p < 0.001$).
D. Lee et al. (2019)	**Study type**: CS; **Age (years)**: 22.6 ± 2.4; **Sample size (n)**:88; **Country**: Korea; **Population:** General population	This article did not include the OR value for determining health problems caused by SA.	Subjects with problematic smartphone use had smaller grey matter volume in the right OFC, which correlated with higher SA scores.
F. Lin et al. (2012)	**Study type**: CS; **Age (years)**: 17.4; **Sample size (n)**:33; **Country**: China; **Population:** Adolescents	This article lacks the OR value to identify health issues resulting from IA.	IA had lower FA than controls, with significant negative correlations between FA values in the left genu of the corpus callosum and SCARED and YIAS.
Liu et al. (2010)	**Study type**: CC; **Age (years)**: 20.5; **Sample size (n)**:38; **Country**: China; **Population:** college students	This article did not address the OR value for establishing medical issues brought on by IA.	The IA group found increased ReHo brain regions in the cerebellum, brainstem, and temporal gyrus.
Park et al. (2017)	**Study type**: CC; **Age (years)**: 13.48; **Sample size (n)**:39; **Country**: Korea; **Population:** Adolescents	No computed OR value or information was provided to calculate the OR value to link health issues as an outcome of GA.	GA subjects showed greater impulsiveness in all three second-order factors, with higher global but lower local efficiency.
Schmitgen et al. (2020)	**Study type**: CS; **Age (years)**: 22.55; **Sample size (n)**:42; **Country**: Germany; **Population:** General population	This article did not provide a computed OR value or data to compute the OR value to associate health problems due to SA.	There were negative associations between particular SA subscores and the MPFC, ACC, precuneus, and precentral gyrus.

(continued)

Table 2. Continued

Author	Summary of Study	Reason for Exclusion from Meta-analysis	Results
Siste et al. (2022)	**Study type**: CS; **Age (years)**: 14.15; **Sample size (n)**:60; **Country**: Indonesia; **Population:** high school students	There was no computed OR value or data to compute the OR value to associate health problems due to IA.	IA adolescents exhibited increased connectivity between the nodes of the CEN and SN but decreased connectivity among the nodes of the CEN and DMN.
Weng et al. (2013)	**Study type**: CC; **Age (years)**: 15.90; **Sample size (n)**:34; **Country**: China; **Population:** NA	The study did not include a computed OR value or data to generate the OR value for related health problems due to GA.	GA patients had significant grey matter atrophy and lower FA in the right orbitofrontal cortex, insula, and external capsule.
Zou et al. (2021)	**Study type**: CS; **Age (years)**: 19.02 ± 0.83; **Sample size (n)**: 266; **Country**: China; **Population:** college students	This article provided neither a computed OR value nor information to compute the OR value to associate health issues resulting from SA.	The GMV of the ACC moderated the negative correlation between SA and depressive symptoms.
Zou et al. (2022)	**Study type**: CS; **Age (years)**: 19.05 ± 0.81; **Sample size (n)**: 238; **Country**: China; **Population:** college students	No computed OR value or information to compute the OR value to correlate health issues as a result of SA was reported in the publication.	SA is positively associated with depressive symptoms moderated by iFC.
Y. Wang et al. (2016)	**Study type:** CS; **Age (years)**: 21.67; **Sample size (n)**: 68; **Country**: China; **Population:** college students	The publication did not include a computed OR value or data to compute the OR value to correlate health issues caused by SA.	The SA group had lower GMV than controls in regions such as the rsFG and Thal, as well as lower FA and AD measures of WM integrity in bilateral hippocampus CgH. The FA of the CgH was similarly adversely linked with SA scores.
Tsilosani, Chan, Steffens, Bolton, and Kowalczyk (2023)	**Study type:** CS; **Age (years)**: NA; **Sample size (n)**: 14; **Country**: United States; **Population:** college students	The study lacked a computed OR value or data to determine the OR value for SMA-related health issues.	SMA is linked to anxiety, depression, and worry, but not substance use disorders. It increases behavioral inhibition and anticipatory pleasure but not consummatory pleasure.
Kubo, Masuyama, and Sugawara (2023)	**Study type:** CS; **Age (years)**: 12–15; **Sample size (n)**: 962; **Country**: Japan; **Population:** adolescents	The article did not include a computed OR value nor details to estimate the OR value to correlate health concerns caused by IA.	BIS and BAS-FS mediate depression-internet addiction association, while BAS-FS improves mental health but directly enhances addiction.

Note: case-control (CC); cross-sectional (CS); not available (NA)); Odds ratio (OR); gaming addiction (GA); dorsolateral prefrontal cortex (DLPFC); smartphone addiction (SA); Social media addiction (SMA); complexity of cortical folding (CCF); right caudal (cACC); anterior cingulate cortex (ACC); Gray matter volumes (GMV); Equine-assisted activities and therapies (EAAT); Korean Experiences in Close Relationships Scale Revised version (K-ECRS); functional connectivity (FC); telomere/single copy (T/S) ratio; orbitofrontal cortex (OFC); Internet addiction (IA); Fractional anisotropy (FA); Screen for Child Anxiety Related Emotional Disorders (SCARED); Young's Internet Addiction Scale (YIAS); regional homogeneity (ReHo); medial prefrontal cortex (MPFC); central executive networks (CEN); salience network (SN); default mode networks (DMN); problematic mobile phone usage (PMPU); intrinsic functional connectivity (iFC); resting-state functional connectivity (rsFC); thalamus (Thal); axial diffusivity (AD); white matter (WM); cingulum bundle fibers (CgH); behavioral inhibition and activation systems(BIS/BAS); BAS-fun-seeking (BAS-FS).

this demographic, many studies rely on self-reported data (e.g., screen time logs, health surveys), which may not fully capture the extent of this association (Barone Gibbs et al., 2015; Hale & Guan, 2015). Self-report measures can be subject to biases, such as recall error or social desirability, potentially affecting the validity of the findings (Latkin, Edwards, Davey-Rothwell, & Tobin, 2017). Consequently, while the physical health risks associated with digital addiction are concerning, they warrant cautious interpretation due to methodological limitations (Odgers & Jensen, 2020). Furthermore, the predominance of cross-sectional designs and lack of objective health measurements in many studies limit causal inferences (Amy Orben & Andrew K. Przybylski, 2019; Twenge & Campbell, 2018).

Table 3. Outcome definitions, outcome numbers, and combined study sample sizes for each outcome

	outcome numbers	countries(n)	combined study sample size	references
Weight: Obesity (7, CS); Overweight (9, CS & 1 CC); Underweight (4, CS)	21	13	20,823	(Alotaibi et al., 2022; Aşut et al., 2019; Eliacik et al., 2016; Fernández-Villa et al., 2015; Garakani et al., 2021; Islam, Tushar, et al., 2023; Iwasaki et al., 2022; Koyuncu et al., 2014; Nunes et al., 2021; Ouni et al., 2024; Pengpid & Peltzer, 2018; Ramón-Arbués et al., 2021; Suris et al., 2014; Venkatesh et al., 2017; Xu et al., 2020)
Fatigue: Fatigue (1, CS); Mental fatigue (2, CS); Excessive Fatigue (1, CS)	4	3	49,340	(Abuhamdah & Naser, 2023; Ohayon & Roberts, 2021; Stevens et al., 2020; Zhang et al., 2021)
Sedentary lifestyle issues: Fewer than three physical exercise sessions per week (3, CS); Physical inactivity (5, CS); No-Regular physical activity (1, CS)	9	7	94,782	(E. A. Abo-Ali et al., 2022; Alotaibi et al., 2022; Buke et al., 2021; Frydenlund et al., 2023; G. Han et al., 2021; M. A. Mamun et al., 2019; Saffari et al., 2022; Shinetsetseg et al., 2022; Liu et al., 2023)
Poor self-rated health: Poor health (7, CS); Fair or poor general health (5, CS); Sight problems (2, CS); Physical symptom (2, CS)	16	9	37,360	(Aleebrahim et al., 2022; H. Cai, Xi, Zhu, Wang, Han, et al., 2021; Chung et al., 2018; Fernández-Villa et al., 2015; Hossin et al., 2022; Mahmoodi et al., 2018; Mayerhofer et al., 2024; Nunes et al., 2021; Poorolajal et al., 2019; Ustinavičienė et al., 2016; Xu et al., 2020; Liu et al., 2023)
Pain: General pain (3, CS); Headaches (3, CS); Musculoskeletal (1, CS); Eye strain (2, CS); Somatic symptom (3, CS); Neck (7, CS); Upper back (2, CS); Lower back (2, CS); Shoulder (3, CS); Elbow (2, CS); Wrists/hands (2, CS)	30	12	115,089	(Alotaibi et al., 2022; J. An et al., 2014; R. Cerutti, F. Presaghi, V. Spensieri, C. Valastro, & V. Guidetti, 2016; Daniyal et al., 2022; Do & Lee, 2018; Fernández-Villa et al., 2015; W. Guo et al., 2020; Heidarimoghadam et al., 2020; Khalil et al., 2022; Mustafaoglu et al., 2021; Nunes et al., 2021; Hu et al., 2022; Suris et al., 2014; Taha et al., 2019; Tran et al., 2017)
Sleep problem: Insomnia (11, CS & 1 C); Mild Insomnia (2, CS); Moderate Insomnia (2, CS); Severe Insomnia (2, CS); Poor sleep quality (16, CS &1 C); More than normal sleep time (5, CS); Less than normal sleep time (6, CS & 1 C)	47	21	375,722	(Abuhamdah & Naser, 2023; Acikgoz, Acikgoz, & Acikgoz, 2022; A. A. Alageel et al., 2021; Alotaibi et al., 2022; Chau et al., 2024; S. H. Cheng et al., 2012; Choi et al., 2009; Chung et al., 2018; Ekinci et al., 2014; Fernández-Villa et al., 2015; Frydenlund et al., 2023; M. Gao et al., 2022; Hossin et al., 2022; Hu et al., 2024; M. A. Mamun et al., 2020; Mohammed A. Mamun, Hossain, Siddique, Sikder, & Griffiths, 2019; M. A. Mamun et al., 2019; Mayerhofer et al., 2024; Nahidi et al., 2023; Nguyen et al., 2022; Nunes et al., 2021; Ohayon & Roberts, 2021; Okasha et al., 2022; Otsuka et al., 2021; Peltzer et al., 2014; Shen et al., 2021; Suris et al., 2014; Taha et al., 2019; L. Yao et al., 2023; C. F. Yen et al., 2008; C. Zhang et al., 2022; Zhang et al., 2021; Y. Zhang et al., 2024; J. Zhao et al., 2022; Y. Zhao et al., 2021)
Violence: Physical fight within the last year (3, CS); Self-harm (6, CS); cyberbullying (1, CS), Been hit (1, CS); Sexual Violence (1, CS); non-suicidal self-harm (2, CS)	14	6	78,735	(Albikawi, 2023; Chau et al., 2024; F. Cheng et al., 2024; Evren et al., 2014; Gansner et al., 2019; Garakani et al., 2021; Lam et al., 2009; M. P. Lin et al., 2018; Muslić et al., 2023; Okasha et al., 2022; Stevens et al., 2020; L. Zhang et al., 2024)

(continued)

Table 3. Continued

	outcome numbers	countries(n)	combined study sample size	references
Self-reported smoking behavior: Smoking (21, CS & 1 C); Cigarette smoking (3, CS); Daily smoking (3, CS); Tobacco use (7, CS); Current water-pipe (Shisha) Smokers (2, CS); Usage of nicotine (2, CS)	39	18	209,499	(E. A. Abo-Ali et al., 2022; A. A. Alageel et al., 2021; Buke et al., 2021; Chau et al., 2024; Chung et al., 2018; Di Carlo et al., 2024; Do et al., 2017; Esen et al., 2021; Evren et al., 2014; Fernández-Villa et al., 2015; Garakani et al., 2021; L. Guo et al., 2018; Islam, Hasan Apu, et al., 2023; Islam, Tushar, et al., 2023; Jeong et al., 2023; Karimy et al., 2020; Liu et al., 2024; M. A. Mamun et al., 2019; Okasha et al., 2022; Onukwuli et al., 2023; Peltzer et al., 2014; Ramón-Arbués et al., 2021; Rücker et al., 2015; Seyrek et al., 2017; Shen et al., 2021; Shinetsetseg et al., 2022; Sung et al., 2013; Tran et al., 2017; Venkatesh et al., 2017; S. Y. Yang et al., 2019; Younes et al., 2016; Yücens & Üzer, 2018; Zenebe et al., 2021)
Problematic alcohol use: Alcohol use (16, CS & 2 C); Heavy drinking (7, CS);	25	13	212,112	(Borges et al., 2023; Buke et al., 2021; Chung et al., 2018; Do et al., 2017; Esen et al., 2021; Fernández-Villa et al., 2015; Garakani et al., 2021; L. Guo et al., 2018; Jeong et al., 2023; Liu et al., 2024; Mayerhofer et al., 2024; Onukwuli et al., 2023; Peltzer et al., 2014; Ramón-Arbués et al., 2021; Shinetsetseg et al., 2022; S. Y. Yang et al., 2019; Younes et al., 2016; Yücens & Üzer, 2018; Zenebe et al., 2021)
Drug use: Drug or substance use (10, CS; 1, C); Cannabis use (4, CS; 1, C); Drug abuse (2, C); Any substance use (1, C)	19	12	150,767	(Borges et al., 2023; Chau et al., 2024; Di Carlo et al., 2024; Evren et al., 2014; Fernández-Villa et al., 2015; Gansner et al., 2019; Garakani et al., 2021; Ko et al., 2006; S. R. Lee et al., 2023; Liu et al., 2024; Onukwuli et al., 2023; Rücker et al., 2015; Sung et al., 2013; Tzang et al., 2022)
Gambling: (3, CS)	3	3	3,738	(Moñino-García et al., 2022; Peltzer et al., 2014; Özparlak & Karakaya, 2022)
ADHD symptoms (5, CS)	5	3	20,422	(A. A. Alageel et al., 2021; Restrepo et al., 2020; Shen et al., 2021; Q. Wu et al., 2022; Y. Zhao et al., 2021)
Depressive symptoms: Depression (54, CS; 2, C & 1, CC); Frequent depressive symptoms (1, CS); Mild depression (1, CS); Moderate Depression (1, CS); Moderate or severe depression (6, CS & 1, C); Clinically significant depression (3, CS)	70	23	640,820	(Al Shawi et al., 2021; A. A. Alageel et al., 2021; Aleebrahim et al., 2022; T.Boonvisudhi & S. Kuladee, 2017 ; Borges et al., 2023; Çelik & Haney, 2023; Chau et al., 2024; H. C. Chen, J. Y. Wang, Y. L. Lin, & S. Y. Yang, 2020; Daniyal et al., 2022; de Paula et al., 2022; Fernández-Villa et al., 2015; Gansner et al., 2019; M. Gao et al., 2022; Garakani et al., 2021; Jeong et al., 2023; Khalil et al., 2022; H. J. Kim et al., 2019; Kojima et al., 2019; Lakhdir et al., 2022; Mayerhofer et al., 2024; N. F. Mohamed et al., 2023; Nahidi et al., 2023; Okasha et al., 2022; Pattanaseri et al., 2022; Peng, 2023; Pereira et al., 2020; Perez-Oyola et al., 2023; Phomprasith et al., 2022; Ramón-Arbués et al., 2021; Restrepo et al., 2020; Saikia et al., 2019; Sharma et al., 2019; Shen et al., 2021; Song et al., 2023; Sujarwoto et al., 2023; Sung et al., 2013; Vengadessin et al., 2024; D. Wang et al., 2023; Yuan et al., 2023; C. Zhang et al., 2022; C. Zhang et al., 2024; M. Zhang et al., 2022; Liu et al., 2023; Feng et al., 2023; Cui et al., 2023)

(continued)

Table 3. Continued

	outcome numbers	countries(*n*)	combined study sample size	references
Stress (15, CS)	15	12	125,459	(H. Dong et al., 2020; M. Gao et al., 2022; Idrees et al., 2024; H. J. Kim et al., 2019; Kwon et al., 2023; Lakhdir et al., 2022; M. A. Mamun et al., 2019; N. F. Mohamed et al., 2023; Ramón-Arbués et al., 2021; Saikia et al., 2019; Sung et al., 2013; Venkatesh et al., 2017; Y. Zhao et al., 2021; Shen et al., 2023)
Anxiety symptoms: Anxiety (28, CS; 1, C & 1 CC); Mild anxiety (1, CS); Moderate anxiety (1, CS); Moderate or severe anxiety(6, CS); Social anxiety (3, CS & 1, C)	42	18	187,347	(E. A. Abo-Ali et al., 2022; Al Shawi et al., 2021; Aleebrahim et al., 2022; Amara et al., 2024; Borges et al., 2023; de Paula et al., 2022; Dien et al., 2023; H. Dong et al., 2020; M. Gao et al., 2022; Khalil et al., 2022; Krishna et al., 2019; G. Kumar et al., 2022; Lakhdir et al., 2022; Lau et al., 2017; Malak & Khalifeh, 2018; M. A. Mamun et al., 2019; Mayerhofer et al., 2024; N. F. Mohamed et al., 2023; Nahidi et al., 2023; Nguyen et al., 2022; Okasha et al., 2022; Peng, 2023; Perez-Oyola et al., 2023; Ramón-Arbués et al., 2021; Restrepo et al., 2020; Saikia et al., 2019; Sharma et al., 2019; Shen et al., 2021; Stevens et al., 2020; Vengadessin et al., 2024; D. Wang et al., 2023; B. Yao et al., 2013; Ye et al., 2016; J. Y. Yen et al., 2008; C. Zhang et al., 2022; M. Zhang et al., 2022; Y. Zhao et al., 2021; Cui et al., 2023)
Suicide: Suicide attempt (16, CS); Suicidal ideation (15, CS); Suicide plans (5, CS)	36	8	540,749	(Chau et al., 2024; Evren et al., 2014; Gansner et al., 2019; L. Guo et al., 2018; W. Guo et al., 2020; Huang et al., 2020; Khalil et al., 2022; H. J. Kim et al., 2019; K. M. Kim et al., 2020; S. R. Lee et al., 2023; Mahmoud et al., 2023; Okasha et al., 2022; Poorolajal et al., 2019; Shen et al., 2021; Shinetsetseg et al., 2022; Stevens et al., 2020; Tan et al., 2023; W. Wang et al., 2019; Y. Zhang et al., 2024)
Eating Disorders: (3, CS)	3	2	1,613	(Banna et al., 2023; Mayerhofer et al., 2024)
Other mental health: Psychological distress (11, CS); Emotional problems (3, CS); Lonely (3, CS); Psychoticism (4, CS & 1, C); Paranoid ideation (4, CS &1 CC); Mental health bad/very bad (6, CS &1 C); Psychosexual Disorder (1 CC); Obsessive-Compulsive (1, CS & 1 CC); PTSD (3, CS); Common Mental Disorder (1 CS); Any Mood Disorder (1 C)	42	21	227,088	(Abuhamdah & Naser, 2023; Alotaibi et al., 2022; J. An et al., 2014; U. Asibong et al., 2020; Borges et al., 2023; Daniyal et al., 2022; Evren et al., 2014; Frydenlund et al., 2023; T. Gao et al., 2020; Garakani et al., 2021; Ge et al., 2014; W. Guo et al., 2020; Hossin et al., 2022; Lakhdir et al., 2022; M. A. Mamun et al., 2020; Mayerhofer et al., 2024; K. O. Mohamed et al., 2024; Nunes et al., 2021; Otsuka et al., 2020; Peltzer et al., 2014; Pengpid & Peltzer, 2018; Ran et al., 2024; Rouleau et al., 2023; Rücker et al., 2015; Stevens et al., 2020; Suris et al., 2014; Tsitsika et al., 2011; Vigna-Taglianti et al., 2017; B. Yao et al., 2013; J. Y. Yen et al., 2008; Zenebe et al., 2021; Y. Zhao et al., 2021)

Note: Data for outcome are definition (number of samples, study type), CS = cross section, C = cohort study, CC = case-control study.

The meta-analysis revealed that youth with digital addiction have 25% greater odds of being overweight or obese. This finding is particularly concerning given the rising prevalence of overweight and obesity globally (Ng et al., 2014), with previous established links between excessive screen time and sedentary behavior (Carson et al., 2015), which are often associated with digital addiction, to increased odds of being overweight and obese in youth (Fang, Mu, Liu, & He, 2019; Haghjoo, Siri, Soleimani, Farhangi, & Alesaeidi, 2022; Robinson et al., 2017; Wu, Amirfakhraei, Ebrahimzadeh, Jahangiry, & Abbasalizad-Farhangi, 2022).

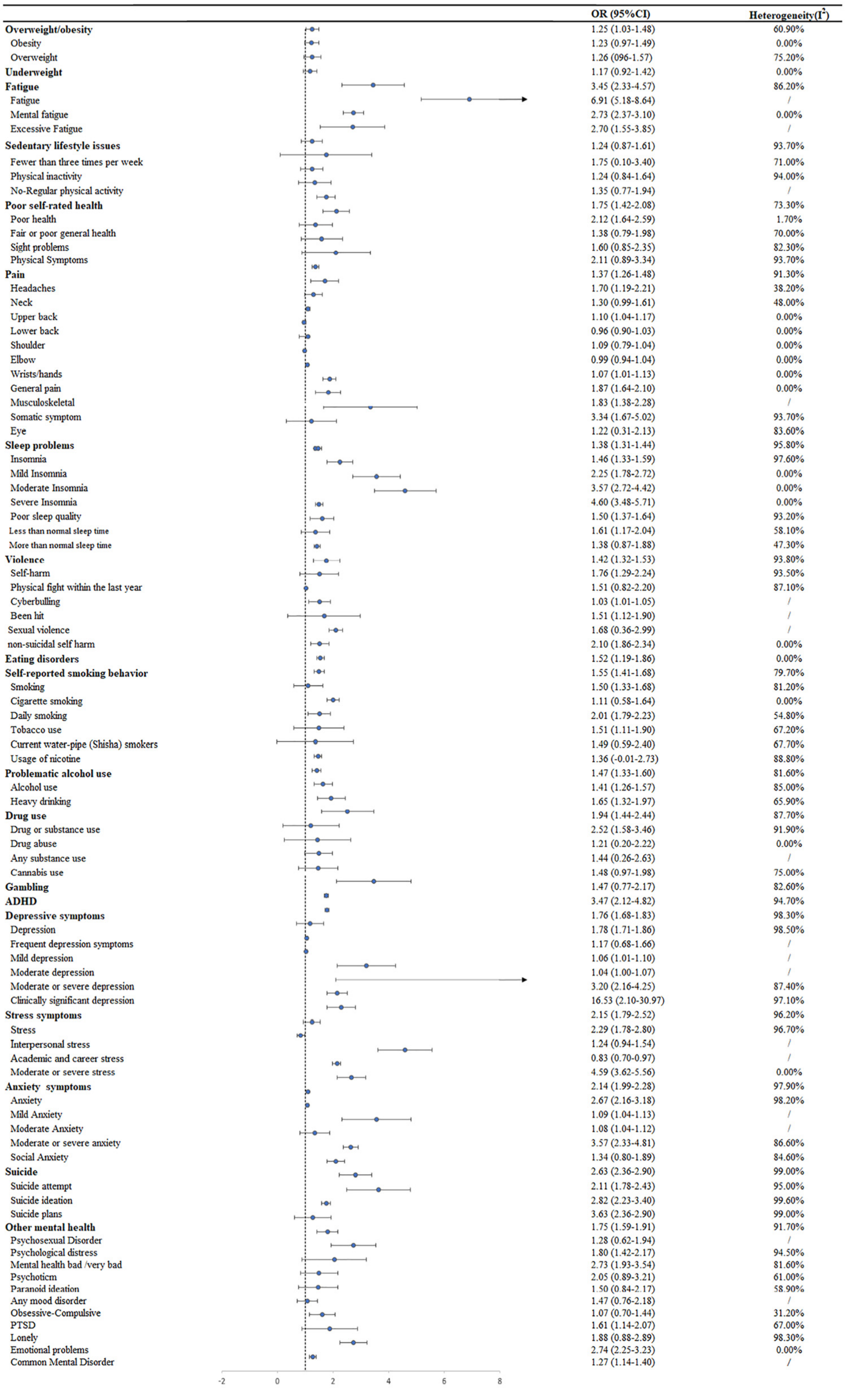

Fig. 2. Pooled ORs from random-effects meta-analyses

Note: OR = odds ratio, 95%CI = 95% confidence interval attention; deficit hyperactivity disorder: ADHD, Post-traumatic stress disorder: PTSD.

Digital addiction is consistently associated with sleep problems, including insomnia and poor sleep quality. Particularly evening screen exposure, may disrupt the natural sleep-wake cycle and suppress melatonin production, a hormone essential for sleep regulation (Burgess & Fogg, 2008; Hale et al., 2018; Hale & Guan, 2015;

Higuchi, Motohashi, Liu, & Maeda, 2005; Nakshine, Thute, Khatib, & Sarkar, 2022). These findings support the growing evidence linking digital addiction to sleep disturbances among youth (Dresp-Langley & Hutt, 2022; LeBourgeois et al., 2017; Levenson, Shensa, Sidani, Colditz, & Primack, 2016; Nakshine et al., 2022; Pirdehghan, Khezmeh, & Panahi, 2021).

Additionally, youth with digital addiction frequently report headaches, neck pain, and musculoskeletal problems, which could be attributed to poor posture and repetitive strain injuries associated with prolonged use of devices (Hale & Guan, 2015; Nakshine et al., 2022). Furthermore, digital addiction is linked to poorer self-rated health among youth. This association may be attributed to the detrimental effects of excessive screen time, such as reduced physical activity, disrupted sleep patterns, and increased sedentary behavior, which can contribute to a decline in overall health perceptions (Burgess & Fogg, 2008; Higuchi et al., 2005; Robinson et al., 2017). A decrease in physical activity levels among youth, potentially contributing to overall physical inactivity, is concerning given the importance of regular exercise for overall health and well-being (Biddle, Pearson, Ross, & Braithwaite, 2010). These physical health problems underscore the need for interventions that promote healthy screen time habits and support the physical well-being of youth in the digital age.

Digital addiction and behavioral problems

The relationship between digital addiction and behavioral problems among youth is a pressing concern that necessitates a thorough investigation. This systematic review and meta-analysis revealed a compelling connection between digital addiction and an elevated risk of related behavior. However, many reported associations may be influenced by shared risk factors such as socioeconomic disadvantage, family dysfunction, or pre-existing mental health conditions (A. Orben & A. K. Przybylski, 2019; Andrew K. Przybylski & Netta Weinstein, 2017; Twenge & Campbell, 2018). These confounders may independently predispose youth to both digital overuse and adverse health outcomes (Boers, Afzali, & Conrod, 2020; Ferguson, 2015; Mohammed A. Mamun, Hossain, & Griffiths, 2022), complicating the interpretability of cross-sectional relationships.

Research indicates a significant correlation between digital addiction and risky behavior patterns such as smoking, problematic alcohol use, and drug or substance use (Bányai et al., 2017; Van Rooij, Schoenmakers, Vermulst, Van den Eijnden, & Van de Mheen, 2011). Adolescents with digital addiction may be more likely to use substances as coping mechanisms for underlying psychological distress. Excessive digital engagement may function as a maladaptive coping strategy, exacerbating substance use behaviors.

Neurobiological research suggests that internet activity, gaming cues, nicotine, and alcohol all alter neural networks, activating reward-related brain regions (e.g., striatum, insula, and anterior cingulate cortex) and disrupting dopamine metabolism, which in turn affects the functioning of the reward system (Baik, 2013; Ko et al., 2009, 2013; Zakiniaeiz, Scheinost, Seo, Sinha, & Constable, 2017). These mechanisms may explain the increased odds of smoking and alcohol use among youth with digital addictions. Additionally, digital addiction is associated with a higher likelihood of violent behavior, including self-harm and physical aggression. These findings underscore the need for targeted interventions to mitigate the impact of digital addiction on substance use and violence among youth.

Digital addiction and mental health problems

Digital addiction is associated with several core mental health issues, including suicidal ideation, depressive symptoms, anxiety symptoms, and attention-deficit/hyperactivity disorder (ADHD). Most studies examining these relationships have employed cross-sectional designs, limiting casual interpretation. While significant associations exist between digital addiction and adverse mental health outcomes, the directionality remains unclear—relationships may be unidirectional, bidirectional, or attributable to shared risk factors (e.g., socioeconomic status, family dysfunction, or pre-existing mental health conditions) (González-Bueso et al., 2018).

The findings have consistently demonstrated that digital addiction is closely linked to elevated odds of suicidal thoughts, suicide attempts, and suicide plans among youths, consistent with previous research (Hagihara, Miyazaki, & Abe, 2012). Youth with digital addiction often exhibit negative self-perceptions and heightened vulnerability to mood disorders under stress (Poorolajal et al., 2019; Shen et al., 2020). Lack of familial support, inadequate supervision, and limited opportunities to express emotional distress further exacerbate these risks (Yong, Qi, Tiancheng, Fulan, & Jine, 2017).

Depressive symptoms are robust predictors of problems with digital addiction (Matar Boumosleh & Jaalouk, 2017; Moge & Romano, 2020; Tan, Chen, Lu, & Li, 2016). In a study comparing multiple predictors of digital addiction, depression levels had the strongest correlation, even after accounting for demographics, personality traits, and future time perspective (i.e., the ability to envision and pursue future goals) (Przepiorka, Blachnio, & Cudo, 2019). Given that anxiety is closely related to depression, it is not surprising that it has also been shown to be associated with digital addiction.

Since impulsivity is a common feature of adolescents with digital addiction, ADHD is one of their most common comorbidities. In a recent review, 87% of the included studies found a significant relationship between ADHD and digital addiction (González-Bueso et al., 2018). Our results align with previous studies, which have consistently shown that youth with digital addiction display more severe ADHD symptoms (D. H. Han, Yoo, Renshaw, & Petry, 2018; H. R. Wang, Cho, & Kim, 2018). Traits such as easy boredom and poor self-control, typical features of ADHD, appear to mediate to this association (H. R. Wang et al., 2018).

Digital addiction is also linked to stress, psychosexual disorders, psychological distress, paranoid ideation, obsessive-compulsive tendencies, and post-traumatic stress disorder (Twenge & Campbell, 2018), with a substantial body of research highlighting the detrimental impact of excessive screen time and social media exposure on mental health outcomes among youth (Krossbakken et al., 2018; Moge & Romano, 2020; Tan et al., 2016). Various mental health problems, such as psychosexual disorders, psychological distress, paranoid ideation, obsessive-compulsive tendencies, and post-traumatic stress disorder (PTSD), associated with digital addiction can have far-reaching consequences for the overall psychological well-being of youth (Twenge & Campbell, 2018). The addictive nature of digital devices, coupled with exposure to social media particularly in the context of online bullying, can further amplify psychological distress and the development of mental health disorders (A. K. Przybylski & N. Weinstein, 2017; Twenge, Martin, & Campbell, 2018). These findings underscore mental health disorders as a critical component of the disease burden associated with digital addiction.

Digital addiction and brain function

In addition to mental and physical health, several neurobiological dysfunctions may characterize digital addiction, though current review of neurobiological research on digital addiction remains limited in terms of quantity and methodological rigor. Most available studies are cross-sectional and rely on convenience samples, which restricts our ability to preclude causal inferences. Future research should prioritize longitudinal neuroimaging studies using standardized diagnostic criteria to elucidate the neural mechanisms underlying youth digital addiction.

Studies included in this review found that gray matter volumes (GMV) in the right superior frontal gyrus, right inferior frontal gyrus, bilateral thalamus, right lateral orbitofrontal cortex, left anterior insula, left inferotemporal cortex, and left parahippocampal cortex were smaller in the SA group than in healthy controls (Horvath et al., 2020; D. Lee et al., 2019; Y. Wang et al., 2016). Of particular interest, anterior cingulate cortex (ACC) abnormalities mirror findings in internet addiction research (Zou et al., 2021). The ACC has been identified as part of a reward system that encodes reward prediction errors and plays a crucial role in attentional and motor control processes involving behavioral modification (G. Dong, Huang, & Du, 2011; Hayden, Heilbronner, Pearson, & Platt, 2011; D. Lee, Park, Namkoong, Kim, & Jung, 2018). Thus, changes in GMV in the ACC may be related to SA, and higher anterior cingulate GMV reductions potentially mediating the association between SA and depressive symptoms in youth (Zou et al., 2021).

Moreover, functional MRI studies on digital addiction consistently identify altered brain activity in the ACC and right fusiform gyrus (W. N. Ding et al., 2014; Jin et al., 2016; Qi et al., 2016). Further research has also been conducted to explore the implications of digital addiction on the cognitive and social development of youth (A. K. Przybylski & N. Weinstein, 2017; Twenge et al., 2018) and found that excessive digital media use, including social media platforms, was associated with decreased cognitive abilities, such as decreased attention span, reduced memory function, and lower academic performance (Rosen et al., 2014; Twenge et al., 2018). These findings suggest that digital addiction may hinder cognitive development and academic success (A. K. Przybylski & N. Weinstein, 2017). These findings emphasize the importance of addressing digital addiction to safeguard the mental well-being of youth.

Strengths and limitations

This meta-analysis is the first of its kind to examine the relationship between youth digital addiction and various health outcomes. An extensive database search using various terms and hand search was conducted to characterize the prevalence of digital addiction in this population. The review examined psychological, physical, behavioral, and neurobiological health outcomes across culturally diverse samples.

Despite its contributions, this study has several limitations. First, the current evidence base consists predominantly of cross-sectional studies (n = 159, 92.4%), which precludes causal inferences regarding the relationships between digital addiction and associated health outcomes. It is possible that pre-existing mental or physical health conditions may predispose youth to develop addictive digital behaviors, rather than digital addiction directly causing these conditions. Future longitudinal research is needed to clarify temporal relationships and potential bidirectional effects.

Second, there is a paucity of high-quality prospective studies reporting quantifiable outcomes, as well as a scarcity of neuroimaging studies examining digital addiction in youth. Although, a small number of cohort (n = 6, 3.5%) and case-control studies (n = 7, 4.1%) were included, offering preliminary insights into potential risk factors and associations, prospective designs remain underrepresented in the literature. The limited number of neurobiological studies, combined with methodological variability, constrains the strength of conclusions that can be drawn.

Third, considerable heterogeneity was observed in most pooled estimates, introducing significant uncertainty. Studies with lower methodological quality may tend to report higher odds ratios (ORs), suggesting potential overestimation of association in less rigorous designs. Future research should prioritize high-quality observational studies employing standardized diagnostic criteria and robust sampling methods.

Fourth, some included studies relied on online sampling, volunteer participation, or convenience sampling, increasing the risk of selection bias. Fifth, the current analysis treated “youth” as a broad category (≤25 years) without subgroup analyses by developmental stages (e.g., early adolescence vs. late adolescence). Due to inconsistent age stratification across studies, it was not feasible to explore potential age-related disparities within this demographic in digital addiction patterns. Future research should prioritize subgroup analyses using more granular age bands when sufficient data are available to better understand the developmental differences in digital addiction and its associated health outcomes.

Finally, substantial variability in prevalence rates across studies likely stems from inconsistent diagnostic criteria for digital addiction. Standardized assessment tools are needed to enhance comparability.

Implications and conclusions

The findings of the present study should not independently guide intervention efforts; however, practical implications can be inferred when contextualized within the broader literature on digital addiction and adverse youth health outcomes. It is plausible that interventions promoting healthy screen time habits, encouraging physical activity and exercise, improving sleep hygiene, fostering positive mental health, and supporting individuals struggling with digital addiction (Krossbakken et al., 2018; Twenge & Campbell, 2018) could benefit youth with digital addiction. Collaborative efforts among parents, educators, healthcare professionals, and policymakers (A. K. Przybylski & Weinstein, 2017; Twenge et al., 2018) are likely necessary to address the complex issue of digital addiction and mitigate its detrimental effects on youth health.

Digital addiction among youth is associated with a range of adverse health outcomes, including physical health complications, mental health issues, and behavioral problems. Culturally tailored interventions are imperative, considering the observed regional variations in digital addiction patterns. These findings underscore the necessity of comprehensive strategies that address both individual and environmental factors to prevent and mitigate digital addiction. Given the strong associations between digital addiction and adverse mental and physical health outcomes, policymakers should consider integrating digital literacy and healthy screen time education into school curricula, thereby promoting balanced screen habits through community and parental involvement. Public health campaigns advocating balanced digital engagement, particularly among high-risk youth populations, may help mitigate the long-term consequences of digital overuse.

Future research should prioritize longitudinal designs and multimodal neuroimaging techniques to clarify whether the observed brain differences precede or result from digital addiction. The adoption of standardized diagnostic criteria and validated tools will also enhance consistency and comparability across studies. Establishing a unified, cross-culturally applicable framework will support more effective screening, prevention, and treatment strategies for digital addiction among youth. Continued research, education, and collaboration among various stakeholders are warranted to address this evolving issue and ensure the health and development of the youth in the digital age.

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SUPPLEMENTARY MATERIAL

Supplementary data to this article can be found online at https://doi.org/10.1556/2006.2025.00081.

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